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(54) **Exhaust apparatus for straddle-type vehicles and straddle-type vehicle**

Auspuff für Zweiradfahrzeuge und Zweiradfahrzeug

Appareil d'échappement pour véhicules de type chariot et véhicule de type chariot

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(56) References cited:
DE-A1- 4 006 438 FR-A- 1 347 893
GB-A- 2 158 878 JP-A- 63 001 714
US-A- 4 192 402

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Description

BACKGROUND

5 **[0001]** The present invention relates to an exhaust apparatus (or exhaust device) for a straddle-type vehicle and a straddle-type vehicle.

[0002] A muffler (exhaust apparatus) used in a straddle-type vehicle (for example, a motorcycle) is requested to meet two demands, that is, an exhaust efficiency, at which exhaust gases discharged from an engine should be efficiently discharged, and noise reduction or noise elimination of exhaust noise, which accompanies discharge of exhaust gases

10 **[0003]** In particular, a demand for noise reduction or noise elimination is put forward in these days when regulations of noise are being made rigorous. Accordingly, it is increasingly desired that noise reduction or noise elimination be attained with an exhaust efficiency maintained. Mufflers for motorcycles are disclosed in, for example, JP-A-8-312324 and JP-A-2003-184541.

15 **[0004]** When design of a muffler is thought only in terms of exhaust efficiency, a muffler (exhaust system) is preferably extended straight. However, such muffler is not accommodated in a vehicle body of a motorcycle. Accordingly, in order to lessen an exhaust resistance, a muffler is extended toward the rear of a vehicle body so as not to be bent suddenly as far as possible, which is actually difficult in many cases because of association with a front wheel and a bank angle. Normally, a muffler having an ideal length in terms of engine performance is in small cases accommodated intact in a configuration of a motorcycle, and as compared with design of a muffler for four-wheel passenger cars, much troubles

20 are involved in designing a muffler, a length of which is nearly best in performance, so as to accommodate the same in a configuration of a motorcycle while maintaining a configuration as smooth as possible.

[0005] Also, not only an exhaust efficiency but also a weight of a muffler has a great influence on controllability in motorcycles. That is, since a motorcycle is light in weight, even a weight of around 1 kg has a great influence on the motorcycle and a distant position of a center of gravity of a muffler in addition to a weight of the muffler has an adverse influence on controllability of the motorcycle.

25 **[0006]** On the other hand, in spite of any contrivance on a construction, a muffler volume is needed to some extent in heightening a noise eliminating effect. In order to conform to regulations on noise, which are increasingly made rigorous, a muffler cannot but be made large in many cases. Besides, when a metallic sheet, of which a muffler is made, is thin, it vibrates to increase noise, so that the muffler is by all means liable to be made large in weight. An increase in muffler weight will worsen controllability of a motorcycle.

30 **[0007]** While an exhaust apparatus for a motorcycle can be designed (muffler design) under various restrictions, typically a noise reducing effect cannot be produced unless a muffler is increased in volume, whereby it is not possible to avoid a phenomenon, in which an increase in volume of a muffler brings about a decrease in controllability of a motorcycle. In a muffler in, for example, present four-stroke motocross motorcycles (in particular, sports vehicles), a silencer is typically increased in volume in order to meet noise reduction and running performance, so that the muffler is large and heavy. Current noise regulations are such that current mufflers cannot be made small and light without disregarding noise factors.

35 **[0008]** Under such situation, the inventors of the present invention have tried to realize an exhaust apparatus (muffler), which is small-sized and light while meeting a running performance (exhaust property) and a noise characteristic.

[0009] In this manner, since a structure of a muffler for motorcycles is determined in terms of a variety of reciprocal factors, it has been extremely difficult to realize a muffler, in which reduction in size and weight is achieved and an exhaust efficiency and a noise absorption characteristic are met.

40 **[0010]** The invention seeks to provide a muffler for straddle-type vehicles, in which reduction in size and weight may be achieved while a demand for a noise absorbing characteristic may be met.

SUMMARY

50 **[0011]** Aspects of the invention are specified in the claims. The features of the claims may be combined in combinations other than those specifically set out in the claims.

[0012] An embodiment of the invention can provide an exhaust apparatus (an exhaust device) for a straddle-type vehicle comprising an engine, the exhaust apparatus comprising a tail pipe, a silencer and an exhaust pipe, wherein the exhaust pipe has a volume defined between a first end of said pipe connecting to the engine and a second end of said pipe connecting to or within the silencer to be connected to the engine and a silencer having a volume defined by an inner surface of an outer cylinder of said silencer, minus a volume of the exhaust pipe extending into said silencer and minus a volume of a tail pipe extending into said silencer and said silencer being connected to the exhaust pipe, wherein the volume of the exhaust pipe and the volume of the silencer are equal to each other.

55 **[0013]** In an embodiment, the exhaust apparatus comprises damping means for an improvement of a damping char-

acteristic in a low frequency range, wherein the damping means decreases a level of a primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus.

[0014] In an embodiment, the volume of the exhaust pipe also includes a volume of a cylinder head exhaust port portion.

[0015] In an embodiment, the silencer comprises an inner cylinder accommodated in the outer cylinder, and a punched hole is formed in at least a part of the inner cylinder of the silencer.

[0016] In an embodiment, a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer.

[0017] In an embodiment, the tail pipe is offset relative to the exhaust pipe radially of the silencer.

[0018] In an embodiment, the sound absorbing material comprises at least one of glass wool and stainless steel wool.

[0019] An embodiment has a feature in that the silencer comprises an inner cylinder accommodated in the outer cylinder, and an outside diameter of the tail pipe is smaller than an inside diameter of the inner cylinder of the silencer.

[0020] An embodiment has a feature in that the inside diameter of the inner cylinder is gradually decreased up to a front end of the tail pipe.

[0021] In an embodiment, an air layer is provided between the tail pipe and the inner cylinder.

[0022] In an embodiment, the silencer comprises an inner cylinder accommodated in the outer cylinder, a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer, and a first air layer is provided between the inner wall of the outer cylinder and an outer wall of the sound absorbing material.

[0023] In an embodiment, the exhaust apparatus includes a second air layer provided between the tail pipe and the inner cylinder, and the sound absorbing material is arranged between the second air layer provided between the tail pipe and the inner cylinder, and the first air layer provided between the inner wall of the outer cylinder and the outer wall of the sound absorbing material.

[0024] In an embodiment, a chamber is provided in the exhaust pipe, and a volume of the exhaust pipe also includes a volume of the chamber.

[0025] In an embodiment, a hollow conical structure, for example a cone, which maybe a punched cone, is provided in the silencer. The conical structure may be in the form of a cone with a tip end thereof opened and formed with a hole.

[0026] In an embodiment, the silencer comprises an inner cylinder accommodated in the outer cylinder, the tail pipe is connected to the inner cylinder of the silencer, and the cone is provided at an upstream end of the tail pipe.

[0027] An embodiment has a feature in that an opening hole of the cone has an opening diameter at an upstream end thereof, which is smaller than an opening diameter at a downstream end thereof.

[0028] In an embodiment, the silencer comprises an inner cylinder, and the conical structure includes a first cone connected to the tail pipe, and a second cone, which covers the first cone and is connected to the inner cylinder.

[0029] An assembly can be provided that includes an engine and the exhaust apparatus.

[0030] A straddle-type vehicle according to the invention comprises a straddle-type vehicle provided with such an assembly.

[0031] In an embodiment, the straddle-type vehicle comprises a four-stroke engine.

[0032] In an embodiment, the straddle-type vehicle comprises an off road type motorcycle.

[0033] Since the volume of the exhaust pipe and the volume of the silencer are made substantially equal to each other, it is possible to improve the damping characteristic of the exhaust apparatus in a low frequency range (in particular, a primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus) whereby it is possible to achieve a decrease in noise value. Since an improvement in damping characteristic can be achieved by making a volume of the exhaust pipe and a volume of the silencer close to each other instead of an increase in volume of the exhaust apparatus, it is possible to avoid an increase in weight of the exhaust apparatus, so that it is possible to realize a small-sized exhaust apparatus for a straddle-type vehicle. As a result, it is possible to improve a motorcycle in controllability or kinematical performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Embodiments of the invention are described, by way of example only, with reference to the accompanying drawings.

[0035] Fig. 1 is a side view showing a motorcycle comprising a muffler according to an embodiment of the invention.

[0036] Fig. 2(a) is a perspective view showing the muffler according to the embodiment of the invention, Fig. 2(b) is a view schematically showing an engine 50, and Fig. 2(c) is a perspective view showing a muffler including a chamber 21.

[0037] Fig. 3 is a view schematically showing the structure of the muffler according to the embodiment of the invention.

[0038] Figs. 4(a) and 4(b) are perspective views showing the structures of the muffler according to the embodiment of the invention and a muffler of a comparative example.

[0039] Fig. 5 is a graph making a comparison in damping characteristic between the muffler (Embodiment 1 and Embodiment 2) according to the embodiment of the invention and the muffler of the comparative example.

[0040] Figs. 6(a) to 6(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0041] Figs. 7(a) and 7(b) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0042] Figs. 8(a) to 8(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0043] Figs. 9(a) and 9(b) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0044] Figs. 10(a) to 10(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0045] Figs. 11(a) to 11(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0046] Fig. 12 is a side view showing a motorcycle comprising the muffler of the comparative example.

DESCRIPTION OF EMBODIMENTS

[0047] Embodiments of the invention will be described below, by way of example, with reference to the drawings. The invention is not limited to the following embodiments.

[0048] Fig. 1 shows a motorcycle 1000, on which an exhaust apparatus according to an embodiment of the invention is mounted. The exhaust apparatus 100 is connected to an engine 50. The exhaust apparatus 100 includes an exhaust pipe 20 and a silencer 10. In addition, the exhaust apparatus 100 includes the silencer 10 is in some cases referred to as "muffler" in the specification of the present application for the sake of convenience.

[0049] The muffler 100 according to the embodiment includes the exhaust pipe 20 connected to the engine 50 of the motorcycle 1000, and the silencer 10 connected to the exhaust pipe 20. With a construction shown in Fig. 1, a tail pipe 30 is connected to the silencer 10.

[0050] A state, in which the muffler 100 according to the embodiment is removed from the motorcycle 1000, is shown in Fig. 2(a). The exhaust pipe 20 and the silencer 10 of the muffler 100 shown in Fig. 2(a) are formed with members for mounting to a vehicle body. The muffler 100 according to the embodiment is one for four-stroke engines and the motorcycle 1000 shown in Fig. 1 is an off road vehicle. In addition, in the exhaust pipe 20 shown in Fig. 2(a), its end connected to the engine 50 mounts thereto a cylinder head exhaust port portion 22.

[0051] The exhaust pipe 20 connects to an exhaust hole of the engine 50 as shown in Fig. 2 (b) to lead exhaust gases from the engine 50 to the silencer 10. In an example as shown, the cylinder head exhaust port portion 22 of the exhaust pipe 20 is connected to the engine 50. The silencer 10 has a noise eliminating function to discharge exhaust gases led from the exhaust pipe 20 outside. In the case where the tail pipe 30 is connected to the silencer 10, exhaust gases are discharged outside from the tail pipe 30. In addition, a chamber 21 can be further provided in the exhaust pipe 20 as shown in Fig. 2(c). In this case, exhaust gases from the engine 50 are once expanded in the chamber 21 and then led to the silencer 10 to be discharged outside.

[0052] Fig. 3 schematically shows the structure of the muffler 100 according to the embodiment. The muffler 100 according to the embodiment is structured such that a volume (V_p) of the exhaust pipe 20 is substantially equal to a volume (V_c) of the silencer 10.

[0053] Here, the volume (V_c) of the silencer 10 is a volume obtained by subtracting a volume occupied therein by the exhaust pipe 20 from an interior of the silencer 10. Also, in the case where the tail pipe 30 is connected to the silencer 10, the volume (V_c) of the silencer 10 is a volume obtained by subtracting a volume occupied therein by the exhaust pipe 20 and the tail pipe 30 from an interior of the silencer 10. Also, in the case where the chamber 21 is formed in the exhaust pipe 20, a volume of the chamber 21 constitutes a part of a volume occupied by the exhaust pipe 20 and a volume (V_h) of the cylinder head exhaust port portion 22 also constitutes a part of a volume occupied by the exhaust pipe 20.

[0054] Since the muffler 100 according to the embodiment is structured so that the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other, it is possible to improve a damping characteristic of a low frequency range of the muffler 100, in particular, a primary resonance frequency f_1 (More specifically, a primary resonance frequency f_1 of an exhaust pipe length of the exhaust pipe 20; referred below in some cases to as "a primary resonance frequency f_1 of a muffler" for convenience' sake). When a noise value in a low frequency range is decreased, sound waves having a large energy can be reduced in volume, so that the noise value can be decreased only by damping a noise value of a primary resonance frequency (f_1) of the muffler (Specifically, damping can be achieved until regulations can be met).

[0055] With the construction of the embodiment, an improvement in damping characteristic can be achieved by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 close to each other instead of an increase in muffler volume, so that it is possible to avoid an increase in muffler weight. That is, the muffler 100 according to the

embodiment includes damping means for an improvement in damping characteristic in a low frequency range (in particular, a primary resonance frequency f_1) and the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other to thereby realize the damping means, so that it is not necessary to make the muffler 100 larger in volume than needed and there is no need for any separately independent, new member as damping means, thus enabling realizing a small-sized muffler 100.

[0056] As a specific example, the structure of the muffler 100 according to the embodiment will be described with reference to Fig. 4. Fig. 4(a) shows a muffler 100 having a structure according to the embodiment and Fig. 4(b) shows a muffler 200 as a comparative example.

[0057] Exhaust pipes 20 and 20A shown in Figs. 4(a) and 4(b) are substantially equal to each other in volume but silencers 10 and 10A are considerably different in volume from each other.

[0058] The silencer 10A shown in Fig. 4(b) has a considerably larger volume than that of the exhaust pipe 20A according to a typical design technique in order to obtain a favorable noise eliminating characteristic (damping characteristic). Specifically, the volume of the silencer 10A exceeds twice the volume of the exhaust pipe 20A, and more specifically, is about 2.5 times the latter.

[0059] On the other hand, the silencer 10 shown in Fig. 4(a) has a volume near to the volume of the exhaust pipe 20 contrary to the typical design technique. Specifically, the volume of the silencer 10 is nearly 1.4 times or less the volume of the exhaust pipe 20. More specifically, it is desired that the volume of the silencer 10 be in the range of 1.2 to 0.7 times the volume of the exhaust pipe 20.

[0060] Making a comparison in weight between the both, the weight of the silencer 10 amounts only to around 60 % of the weight of the silencer 10A. A decrease in weight of the silencer 10 not only produces an effect of a decrease in total weight of the motorcycle 1000 but contributes much to an improvement in controllability of the motorcycle 1000 since a member or members positioned distant from a vehicle body center (or, a center of gravity of a vehicle body) of the motorcycle 1000 can be reduced in weight.

[0061] Fig. 12 shows a construction, in which the muffler 200 of a comparative example shown in Fig. 4(b) is mounted to a motorcycle. Making a comparison between both a motorcycle 2000 shown in Fig. 12 and the motorcycle 1000, according to the embodiment, shown in Fig. 1, it is possible to understand how small the muffler becomes in size and volume. As described above, a technical meaning that a small-sized and lightweight muffler 100 could be developed in that situation, in which a muffler cannot but be increased in volume in a typical muffler design in order to obtain a favorable noise eliminating characteristic, is very great.

[0062] Also, while being described later, the muffler 100 according to the embodiment can decrease a noise value further than the muffler 200, which is large in muffler volume. This demonstrates in double meaning that the muffler 100 according to the embodiment has an excellent, technical meaning.

[0063] Fig. 5 is a graph illustrating damping characteristics of the muffler 100 according to the embodiment and the muffler 200 of the comparative example. The damping characteristic of the muffler 100 according to the embodiment is indicated by plots in Embodiment 1 and Embodiment 2 while the damping characteristic of the muffler 200 is indicated by plots in the comparative example.

[0064] In a low frequency range, Embodiment 1, Embodiment 2 and the comparative example are substantially the same in a damping characteristic of f_0 (damping level (dB)) but it is found that Embodiment 1 and Embodiment 2 are favorable in a damping characteristic (damping level (dB)) of f_1 (primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus) as compared with the comparative example. In other words, Embodiment 1 and Embodiment 2 are low in noise value of f_1 as compared with the comparative example. The reason why the noise value of f_1 is small in Embodiment 1 and Embodiment 2 is that the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are substantially equal to each other.

[0065] With that construction, in which the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other, the reason why the noise value in a low frequency range (in particular, f_1) can be decreased is as follows. If a muffler were composed of only the exhaust pipe 20 (without the silencer 10), f_1 would be a resonance frequency of 1/4 wavelength determined by an exhaust pipe length and be suddenly changed into a resonance frequency, at which the both parts (20, 10) were coupled together, in a configuration, in which the silencer 10 were added to the exhaust pipe 20. Here, a strongest coupled state corresponds to the case where the both parts (20, 10) are equal to each other in resonance frequency, which means in other acoustic words that the both parts are equal to each other in volume, and when a sound absorbing material is filled in one of them in this state, it is possible to efficiently damp the frequency.

[0066] Also, when the resonance frequency f_1 is to be decreased, volumes (V_p , V_c) of the exhaust pipe 20 and the silencer 10 are influenced thereby, but even when the exhaust pipe 20 is bent, there is caused no substantial influence, which provides an advantage in design.

[0067] In addition, as described above, even in the case where, for example, the chamber 21 is provided on the exhaust pipe 20 and a part of the exhaust pipe 20 is bulged, a design will do, in which the volume (V_p) of the exhaust pipe 20 includes a volume of the chamber 21 and the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the

silencer 10 are made close to each other. In addition, the same is also the case with a volume of the cylinder head exhaust port portion 22.

[0068] In addition, a frequency f_0 (Hz) generated by resonance of the whole muffler can be found by, for example, the following formula in the construction shown in Fig. 3.

$$f_0 = (c/2\pi) \cdot \{S/(V \cdot L)\}^{1/2} \dots \text{(Formula)}$$

[0069] Here, "c" indicates a velocity of sound, "V" indicates an exhaust system volume (that is, "Vp + Vc"), "L" indicates a length of the tail pipe 30, and "S" indicates a cross sectional area of the tail pipe 30.

[0070] When a ratio of the volume (Vp) of the exhaust pipe 20 and the volume (Vc) of the silencer 10 is ideally made 1:1 in the graph of damping characteristic shown in Fig. 5, the noise value of f_1 in Embodiment 1 and Embodiment 2 can be further damped.

[0071] Since the exhaust pipe 20 is actually formed as shown in, for example, Fig. 4 to be bent in order to meet various design conditions and the size and weight of the silencer 10 is also determined in conformity to other conditions (vehicle body weight, vehicle body balance, etc.), however, it is unnecessary in many cases to stick the ratio of the volume (Vp) of the exhaust pipe 20 and the volume (Vc) of the silencer 10 to an ideal 1:1 provided that an effect of a decrease in noise value is produced. That is, provided that a desired effect of a decrease in noise value is produced by making the volume (Vp) of the exhaust pipe 20 and the volume (Vc) of the silencer 10 close to each other contrary to a technical thought (for example, $Vc/Vp > 2$) that it is desirable in a typical muffler design to make the silencer 10 large in volume, it is possible to change a design of the exhaust pipe 20 and the silencer 10 in that range, in which such effect is produced (as an example, 1.2 times to 0.7 times).

[0072] In the graph shown in Fig. 5, it is found that the damping characteristic of the muffler in Embodiment 1 and Embodiment 2 is favorable (that is, noise can be decreased) in a low frequency range (for example, in the order of 600 to 800 Hz), and the comparative example demonstrates a favorable damping characteristic in a frequency range therebeyond. Accordingly, with the muffler 100 according to the embodiment of the invention, a decrease in noise component in a low frequency range is achieved by damping means (damping means for an improvement of a damping characteristic in a low frequency range), which is realized by making the volume (Vp) of the exhaust pipe 20 and the volume (Vc) of the silencer 10 substantially equal to each other, and a decrease in noise component in a frequency range therebeyond can also be achieved by other techniques.

[0073] Modifications of the muffler 100 according to the embodiment will be described below with reference to Figs. 6 to 11. The respective figures schematically show a structure of the silencer 10 in the muffler 100 according to the embodiment, (a) being lateral, cross sectional views, and (b) being cross sectional views as viewed from the rear of a vehicle body. In addition, (c) are partially enlarged views in (a).

[0074] The silencer 10 shown in Fig. 6 comprises an outer cylinder 10a and an inner cylinder 10b accommodated in the outer cylinder 10a. Punched holes 13 are formed in at least a part (region P) of the inner cylinder 10b of the silencer 10.

[0075] The punched holes 13 are small holes formed in the silencer 10 (here, the inner cylinder 10b) and serve to enable energy of exhaust gases, which are introduced from the exhaust pipe 20, to be led to the outer cylinder 10a through the small holes. In an example shown in Fig. 6, a sound absorbing material 15 is filled in a manner to come into close contact between an inner wall of the outer cylinder 10a and an outer wall of the inner cylinder 10b.

[0076] The sound absorbing material 15 is a material capable of absorbing sound waves and can use, for example, glass wool, stainless steel wool (SUS wool), aluminum wool, ferrite, asbestos, etc. In this example, glass wool is used as the sound absorbing material 15. The sound absorbing material 15 fairly absorbs a high frequency sound but is less effective in low frequency sound, so that a synergistic effect is produced when combined with the construction of the muffler 100 according to the embodiment.

[0077] In this example, a SUS wool 15b is provided on the outer wall of the inner cylinder 10b and a glass wool 15a is provided on an outer periphery thereof. In other words, the SUS wool 15b is provided on the outer wall of the inner cylinder 10b and the glass wool 15a is provided on the inner wall of the outer cylinder 10a. Also, the inner cylinder 10b is gradually decreased in inside diameter up to a front end of the tail pipe 30. With a silencer 10 shown in Fig. 7, an air layer 17 is formed between a tail pipe 30 and an inner cylinder 10b. Specifically, an outside diameter d of the tail pipe 30 is smaller than an inside diameter D of the inner cylinder 10b of the silencer 10. In this example, punched holes (region P) are formed in as far as a region (a region, in which the air layer 17 is positioned), in which the tail pipe 30 is positioned. In addition, a cross sectional structure of the silencer 10 shown in Fig. 7 is substantially the same as that shown in the partially enlarged view of Fig. 6(c).

[0078] The construction shown in this example can incorporate therein a damping characteristic, in which noise elimination is achieved by varying (enlarging) a pipe (cylinder) in cross sectional area, and such combination makes it possible to regulate the damping characteristic of the muffler 100 according to the embodiment. Specifically, the pipe

(cylinder) is changed in cross sectional area to enable obtaining a damping characteristic, in which sounds mainly in a low frequency range are eliminated. Also, the provision of the air layer 17 enables producing both effects of noise reduction by the sound absorbing material 15 and noise reduction by pipe bulging.

[0079] The silencer 10 shown in Fig. 8 has a structure similar to that in Fig. 6, but a sound absorbing material 15 is arranged on an outer wall of an inner cylinder 10b and an air layer 19 is present on an inner wall of an outer cylinder 10a, in which no sound absorbing material 15 is filled.

[0080] Here, the sound absorbing material 15 comprises a combination of SUS wool 15b and glass wool 15a in the same manner as that shown in Fig. 6. In addition, as shown in Fig. 8(c), a partition 10c, which supports the sound absorbing material 15 (15a, 15b), is provided and punched holes 13 are formed on the partition 10c.

[0081] With such construction, it is possible to regulate a damping characteristic of the muffler 100 according to the embodiment owing to both effects of noise reduction by the sound absorbing material 15 and noise reduction by pipe bulging.

[0082] A silencer 10 shown in Fig. 9 incorporates a feature of the structure shown in Fig. 7 into the structure shown in Fig. 8 such that an air layer 17 is formed between a tail pipe 30 and an inner cylinder 10b, and such structural feature (that is, a structural feature that the sound absorbing material 15 is arranged between the air layer (first air layer) 19 provided between the inner wall of the outer cylinder 10a and the outer wall of the sound absorbing material 15 and the air layer (second air layer) 17 provided between the tail pipe 30 and the inner cylinder 10b) regulates a damping characteristic of the muffler 100 according to the embodiment. In addition, a cross sectional structure of the silencer 10 shown in Fig. 9 is substantially the same as that shown in the partially enlarged view of Fig. 8(c).

[0083] In addition, the silencer 10 according to the embodiment is not limited to a structure, which comprises the outer cylinder 10a and the inner cylinder 10b accommodated in the outer cylinder 10a, but can adopt a structure shown in Fig. 10. That is, it suffices to design a muffler 100 having a desired damping characteristic by the use of further means, which combines with damping means in a low frequency range, which is realized by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 substantially equal to each other, to enable reinforcing the damping means. Here, the sound absorbing material 15 in Fig. 10(c) comprises, for example, SUS wool, or glass wool, or a combination thereof.

[0084] Also, with a silencer 10 shown in Fig. 10, a tail pipe 30 is offset relative to an exhaust pipe 20 radially of the silencer 10. By doing this, even when an air layer about the exhaust pipe 20 is decreased in cross sectional area by a sound absorbing material 15, such decrease can be compensated for by a cross sectional area of the tail pipe 30.

[0085] A construction, in which a punched cone 32 is arranged in a silencer 10 as shown in, for example, Fig. 11, can be adopted as an example of such further means.

[0086] The punched cone 32 comprises a member, which is in the form of a cone with a tip end thereof opened and formed on a cone-shaped side 35 with punched holes 13, and by which an effect of noise absorption can be produced and a directly transmitting sound of exhaust noise can be decreased. The punched cone 32 has a truncated cone shape.

[0087] An opening hole 37 provided on the punched cone has an opening diameter at an upstream end thereof, which is made smaller than an opening diameter at a downstream end thereof. Thereby, it is possible to prevent direct transmission of noise, thus enabling improving a damping effect. It is possible to arrange one or plural punched cones 32 within the silencer 10. According to the embodiment, the punched cones 32 are provided in two locations (32a, 32b) on the inner cylinder 10b and an upstream end of the tail pipe 30. In addition, it is possible to provide only one punched cone 32 instead of several in number and to provide three or more punched cones.

[0088] In addition, "upstream" side and "downstream" side referred to in the specification of the present application mean an upstream side and a downstream side, respectively, in a direction, in which exhaust gases in the muffler flow. In other words, "upstream" side is that side, on which an engine is arranged, and "downstream" side is that side, on which exhaust gases are discharged outside.

[0089] In the example shown in Fig. 11, the punched cone 32 is provided at an end of the tail pipe 30. Specifically, the punched cone includes a first cone 32a connected to the tail pipe 30 and a second cone 32b, which covers the first cone 32a and is connected to the inner cylinder 10b. By providing a plurality (32a, 32b) of the punched cones 32, it is possible to improve a damping effect further effectively.

[0090] In addition, while Fig. 1 shows an off road type motorcycle as an example of the motorcycle 1000, the motorcycle 1000 may be an on road type one. Also, "motorcycle" in the specification of the present application means a motorcycle and means a vehicle, which includes a bicycle with a motor (motorbike) and a scooter and can specifically turn with a vehicle body inclined. Accordingly, a three-wheeler/four-wheeler, at least one of a front wheel and a rear wheel of which has two or more wheels and which is three, four (or more) in the number of tires, can be included in "motorcycle". In addition, applicability is not limited to a motorcycle but to other vehicles capable of making use of the effect of the invention, for example, a so-called straddle-type vehicle, which includes a four-wheeled buggy, ATV (All Terrain Vehicle), and a snowmobile, except a motorcycle.

[0091] There has been described an exhaust device for a straddle-type vehicle, comprising an engine, and an exhaust part including an exhaust pipe connected to the engine and a silencer connected to the exhaust pipe, wherein a volume

of the exhaust pipe and a volume of the silencer are substantially equal to each other

[0092] While the invention has been described with respect to preferred embodiments, such descriptions are not limitative but various modifications are of course possible.

[0093] According to embodiments of the invention, it is possible to provide a muffler for a straddle-type vehicle, which achieves reduction in size and weight while meeting a demand for a noise absorption characteristic.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0094]

10: silencer
 10a: outer cylinder
 10b: inner cylinder
 13: punched hole
 15: sound absorbing material
 17: air layer (second air layer)
 19: air layer (first air layer)
 20: exhaust pipe
 21: chamber
 22: cylinder head exhaust port portion
 30: tail pipe
 32: punched cone
 32a: first cone
 32b: second cone
 50: engine
 100: muffler (exhaust apparatus)
 200: muffler
 1000 motorcycle
 Vc: volume of silencer
 Vp: volume of exhaust pipe
 Vh: volume of cylinder head exhaust port portion
 d: outside diameter of tail pipe
 D: inside diameter of inner cylinder

Claims

1. An exhaust apparatus for a straddle-type vehicle having an engine, the exhaust apparatus comprising a tail pipe, a silencer, and an exhaust pipe;
 wherein the exhaust pipe (20) has a volume (Vp) defined between a first end of said pipe connecting to the engine and a second end of said pipe connecting to or within the silencer to be connected to the engine and the silencer (10) has a volume (Vc) defined by an inner surface of an outer cylinder of said silencer, minus a volume of the exhaust pipe extending into said silencer and minus a volume of the tail pipe extending into said silencer and said silencer being connected to the exhaust pipe,
 wherein the volume of the exhaust pipe (Vp) and volume of the silencer (Vc) are equal to each other.
2. The exhaust apparatus according to claim 1, further comprising damping means for an improvement of a damping characteristic in a low frequency range,
 wherein the damping means decreases a level of a primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus.
3. The exhaust apparatus according to any of claims 1 to 2, wherein the volume of the exhaust pipe (20) also includes a volume of a cylinder head exhaust port portion.
4. The exhaust apparatus according to any preceding claim, wherein the silencer (10) comprises an inner cylinder (10b) accommodated in the outer cylinder, and a hole is formed in at least a part of the inner cylinder of the silencer.

5. The exhaust apparatus according to any preceding claim, wherein a sound absorbing material (15) is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer.
- 5 6. The exhaust apparatus according to claim 5, wherein the sound absorbing material (15) comprises at least one of glass wool and stainless steel wool.
7. The exhaust apparatus according to any preceding claim, wherein the tail pipe is offset relative to the exhaust pipe radially of the silencer.
- 10 8. The exhaust apparatus according to any preceding claim, wherein the silencer comprises an inner cylinder accommodated in the outer cylinder, and an outside diameter of the tail pipe (30) is smaller than an inside diameter of the inner cylinder (10b) of the silencer.
- 15 9. The exhaust apparatus according to claim 8, wherein the inside diameter of the inner cylinder (10b) is gradually decreased up to a front end of the tail pipe.
10. The exhaust apparatus according to claim 8 or claim 9, wherein an air layer is provided between the tail pipe (30) and the inner cylinder (10b).
- 20 11. The exhaust apparatus according to any preceding claim, wherein the silencer comprises an inner cylinder (10b) accommodated in the outer cylinder, and wherein a sound absorbing material (15) is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer, and a first air layer (19) is provided between the inner wall of the outer cylinder and an outer wall of the sound absorbing material.
- 25 12. The exhaust apparatus according to claim 11, wherein the exhaust apparatus includes a second air layer (17) provided between the tail pipe and the inner cylinder, and wherein the sound absorbing material (15) is arranged between the second air layer provided between the tail pipe and the inner cylinder, and the first air layer provided between the inner wall of the outer cylinder and the outer wall of the sound absorbing material.
- 30 13. The exhaust apparatus according to any preceding claim, wherein a chamber (21) is provided in the exhaust pipe, and a volume of the exhaust pipe (Vp) also includes the volume of the chamber.
- 35 14. The exhaust apparatus according to any preceding claim, further comprising a cone, which is provided in the silencer and in the form of a cone with a tip end thereof opened and formed with a hole.
- 40 15. The exhaust apparatus according to claim 14, wherein the silencer comprises an inner cylinder accommodated in the outer cylinder, and wherein the tail pipe (30) is connected to the inner cylinder of the silencer, and the cone is provided at an upstream end of the tail pipe.
- 45 16. The exhaust apparatus according to claim 15, wherein an opening hole of the cone has an opening diameter at an upstream end thereof, which is smaller than an opening diameter at a downstream end thereof.
- 50 17. The exhaust apparatus according to any of claims 14 to 16, wherein the cone includes a first cone connected to the tail pipe, and a second cone, which covers the first cone and is connected to the inner cylinder.
18. An assembly comprising an engine and an exhaust apparatus according to any preceding claim.
19. A straddle-type vehicle comprising an engine and the exhaust apparatus according to any of claims 1 to 17.
- 55 20. The straddle-type vehicle, according to claim 19, wherein the engine is a four-stroke engine.
21. The straddle-type vehicle, according to claim 19 or claim 20, wherein the straddle type vehicle is an off road type motorcycle.

Patentansprüche

1. Eine Auspuffvorrichtung für ein Grätsch-Typ-Fahrzeug mit einem Motor, wobei die Auspuffvorrichtung folgendes aufweist

5 ein Endrohr, einen Schalldämpfer und ein Auspuffrohr;

wobei das Auspuffrohr (20) ein Volumen (V_p) aufweist, das zwischen einem ersten Ende des Rohrs, das mit dem Motor verbunden ist, und einem zweiten Ende des Rohrs, das mit oder in dem Schalldämpfer verbunden ist, der mit dem Motor verbunden sein soll, definiert ist, und der Schalldämpfer (10) ein Volumen (V_c) aufweist, das durch eine Innenoberfläche eines Außenzylinders des Schalldämpfers definiert ist, minus ein Volumen des Auspuffrohrs,

10 das sich in den Schalldämpfer erstreckt, und minus ein Volumen des Endrohrs, das sich in den Schalldämpfer erstreckt, wobei der Schalldämpfer mit dem Auspuffrohr verbunden ist,

wobei das Volumen des Auspuffrohrs (V_p) und das Volumen des Schalldämpfers (V_c) gleich zueinander sind.
2. Die Auspuffvorrichtung gemäß Anspruch 1, die ferner eine Dämpfungseinrichtung aufweist für eine Verbesserung einer Dämpfungseigenschaft in einem Niederfrequenzbereich,

15 wobei die Dämpfungseinrichtung einen Pegel einer primären Resonanzfrequenz einer Auspuffrohrlänge des Auspuffrohrs in der Auspuffvorrichtung verringert.
3. Die Auspuffvorrichtung gemäß einem der Ansprüche 1 bis 2, bei der das Volumen des Auspuffrohrs (20) ebenfalls ein Volumen eines Zylinderkopfauslassöffnungsabschnitts umfasst.

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4. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der der Schalldämpfer (10) einen Innenzylinder (10b) aufweist, der in dem Außenzylinder untergebracht ist, und ein Loch in zumindest einem Teil des Innenzylinders des Schalldämpfers gebildet ist.

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5. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der ein Schall absorbierendes Material (15) zwischen einer Innenwand des Außenzylinders und einer Außenwand des Innenzylinders in dem Schalldämpfer gefüllt ist.
6. Die Auspuffvorrichtung gemäß Anspruch 5, bei der das Schall absorbierende Material (15) zumindest entweder Glaswolle oder Edelstahlwolle aufweist.

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7. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der das Endrohr relativ zu dem Auspuffrohr radial von dem Schalldämpfer versetzt ist.

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8. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der der Schalldämpfer einen Innenzylinder aufweist, der in dem Außenzylinder untergebracht ist, und ein Außendurchmesser des Endrohrs (30) kleiner ist als ein Innendurchmesser des Innenzylinders (10b) des Schalldämpfers.

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9. Die Auspuffvorrichtung gemäß Anspruch 8, bei der der Innendurchmesser des Innenzylinders (10b) bis zu einem Vorderende des Endrohrs allmählich verringert wird.
10. Die Auspuffvorrichtung gemäß Anspruch 8 oder Anspruch 9, bei der eine Luftschicht zwischen dem Endrohr (30) und dem Innenzylinder (10b) vorgesehen ist.

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11. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der der Schalldämpfer einen Innenzylinder (10b) aufweist, der in dem Außenzylinder untergebracht ist, und bei der ein Schall absorbierendes Material (15) zwischen einer Innenwand des Außenzylinders und einer Außenwand des Innenzylinders in dem Schalldämpfer gefüllt ist, und eine erste Luftschicht (19) zwischen der Innenwand des Außenzylinders und einer Außenwand des Schall absorbierenden Materials vorgesehen ist.

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12. Die Auspuffvorrichtung gemäß Anspruch 11, wobei die Auspuffvorrichtung eine zweite Luftschicht (17) umfasst, die zwischen dem Endrohr und dem Innenzylinder vorgesehen ist, und wobei das Schall absorbierende Material (15) zwischen der zweiten Luftschicht, die zwischen dem Endrohr und dem Innenzylinder vorgesehen ist, und der ersten Luftschicht, die zwischen der Innenwand des Außenzylinders und der Außenwand des Schall absorbierenden Materials vorgesehen ist, angeordnet ist.

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13. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, bei der eine Kammer (21) in dem Auspuffrohr vorgesehen ist, und ein Volumen des Auspuffrohrs (V_p) ferner das Volumen der Kammer umfasst.
14. Die Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche, die ferner einen Kegel aufweist, der in dem Schalldämpfer vorgesehen ist und in der Form eines Kegels ist, wobei ein spitzes Ende desselben geöffnet ist und mit einem Loch gebildet ist.
15. Die Auspuffvorrichtung gemäß Anspruch 14, bei der der Schalldämpfer einen Innenzylinder aufweist, der in dem Außenzylinder untergebracht ist, und wobei das Endrohr (30) mit dem Innenzylinder des Schalldämpfers verbunden ist, und der Kegel an einem oberen Ende des Endrohrs vorgesehen ist.
16. Die Auspuffvorrichtung gemäß Anspruch 15, bei der ein Öffnungsloch des Kegels einen Öffnungsdurchmesser an einem oberen Ende desselben aufweist, der kleiner ist als ein Öffnungsdurchmesser an einem unteren Ende desselben.
17. Die Auspuffvorrichtung gemäß einem der Ansprüche 14 bis 16, bei der der Kegel einen ersten Kegel umfasst, der mit dem Endrohr verbunden ist, und einen zweiten Kegel, der den ersten Kegel abdeckt und mit dem Innenzylinder verbunden ist.
18. Eine Anordnung, die einen Motor und eine Auspuffvorrichtung gemäß einem der vorangehenden Ansprüche aufweist.
19. Ein Grätsch-Typ-Fahrzeug, das einen Motor und die Auspuffvorrichtung gemäß einem der Ansprüche 1 bis 17 aufweist.
20. Das Grätsch-Typ-Fahrzeug gemäß Anspruch 19, bei dem der Motor ein Viertaktmotor ist.
21. Das Grätsch-Typ-Fahrzeug gemäß Anspruch 19 oder Anspruch 20, wobei das Grätsch-Typ-Fahrzeug ein Geländemotorrad ist.

Revendications

1. Appareil d'échappement pour véhicule de type à enfourcher présentant un moteur, l'appareil d'échappement comprenant un tuyau arrière, un silencieux, et un tuyau d'échappement; dans lequel le tuyau d'échappement (20) présente un volume (V_p) défini entre une première extrémité dudit tuyau connectant au moteur et une deuxième extrémité dudit tuyau connectant au ou dans le silencieux à connecter au moteur, et le silencieux (10) présente un volume (V_c) défini par une surface intérieure d'un cylindre extérieur dudit silencieux, moins un volume du tuyau d'échappement s'étendant dans ledit silencieux et moins un volume du tuyau arrière s'étendant dans ledit silencieux et ledit silencieux étant connecté au tuyau d'échappement, dans lequel le volume du tuyau d'échappement (V_p) et le volume du silencieux (V_c) sont égaux l'un à l'autre.
2. Appareil d'échappement selon la revendication 1, comprenant par ailleurs un moyen d'atténuation pour une amélioration d'une caractéristique d'atténuation dans une plage de basses fréquences, dans lequel le moyen d'atténuation diminue un niveau de fréquence de résonance primaire d'un tronçon du tuyau d'échappement dans l'appareil d'échappement.
3. Appareil d'échappement selon l'une quelconque des revendications 1 à 2, dans lequel le volume du tuyau d'échappement (20) comporte également un volume d'une partie d'orifice d'échappement de tête de cylindre.
4. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel le silencieux (10) comprend un cylindre intérieur (10b) logé dans le cylindre extérieur, et un trou est formé dans au moins une partie du cylindre intérieur du silencieux.
5. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel un matériau isolant acoustique (15) est rempli entre une paroi intérieure du cylindre extérieur et une paroi extérieure du cylindre intérieur dans le

silencieux.

6. Appareil d'échappement selon la revendication 5, dans lequel le matériau isolant acoustique (15) comprend au moins une laine de verre et une laine d'acier inoxydable.

7. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel le tuyau arrière est décalé par rapport au tuyau d'échappement radialement par rapport au silencieux.

8. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel le silencieux comprend un cylindre intérieur logé dans le cylindre extérieur, et un diamètre extérieur du tuyau arrière (30) est inférieur à un diamètre intérieur du cylindre intérieur (10b) du silencieux.

9. Appareil d'échappement selon la revendication 8, dans lequel le diamètre intérieur du cylindre intérieur (10b) est réduit progressivement jusqu'à une extrémité avant du tuyau arrière.

10. Appareil d'échappement selon la revendication 8 ou la revendication 9, dans lequel une couche d'air est prévue entre le tuyau arrière (30) et le cylindre intérieur (10b).

11. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel le silencieux comprend un cylindre intérieur (10b) logé dans le cylindre extérieur, et dans lequel un matériau isolant acoustique (15) est rempli entre une paroi intérieure du cylindre extérieur et une paroi extérieure du cylindre intérieur dans le silencieux, et une première couche d'air (19) est prévue entre la paroi intérieure du cylindre extérieur et une paroi extérieure du matériau isolant acoustique.

12. Appareil d'échappement selon la revendication 11, dans lequel l'appareil d'échappement comporte une deuxième couche d'air (17) prévue entre le tuyau arrière et le cylindre intérieur, et dans lequel le matériau isolant acoustique (15) est disposé entre la deuxième couche d'air prévue entre le tuyau arrière et le cylindre intérieur, et la première couche d'air prévue entre la paroi intérieure du cylindre extérieur et la paroi extérieure du matériau isolant acoustique.

13. Appareil d'échappement selon l'une ou l'autre revendication précédente, dans lequel une chambre (21) est prévue dans le tuyau d'échappement, et un volume du tuyau d'échappement (V_p) comporte également le volume de la chambre.

14. Appareil d'échappement selon l'une ou l'autre revendication précédente, comprenant par ailleurs un cône qui est prévu dans le silencieux et sous forme d'un cône, une extrémité de pointe de ce dernier étant ouverte et formée avec un trou.

15. Appareil d'échappement selon la revendication 14, dans lequel le silencieux comprend un cylindre intérieur logé dans le cylindre extérieur, et dans lequel le tuyau arrière (30) est connecté au cylindre intérieur du silencieux, et le cône est prévu à une extrémité amont du tuyau arrière.

16. Appareil d'échappement selon la revendication 15, dans lequel un trou d'ouverture du cône présente un diamètre d'ouverture à une extrémité amont de celui-ci qui est plus petit qu'un diamètre d'ouverture à une extrémité aval de celui-ci.

17. Appareil d'échappement selon l'une quelconque des revendications 14 à 16, dans lequel le cône comporte un premier cône connecté au tuyau arrière, et un deuxième cône qui recouvre le premier cône et est connecté au cylindre intérieur.

18. Ensemble comprenant un moteur et un appareil d'échappement selon l'une ou l'autre revendication précédente.

19. Véhicule du type à enfourcher, comprenant un moteur et l'appareil d'échappement selon l'une quelconque des revendications 1 à 17.

20. Véhicule du type à enfourcher selon la revendication 19, dans lequel le moteur est un moteur à quatre temps.

- 21.** Véhicule du type à enfourcher selon la revendication 19 ou la revendication 20, dans lequel le véhicule du type à enfourcher est une motocyclette de type tout terrain.

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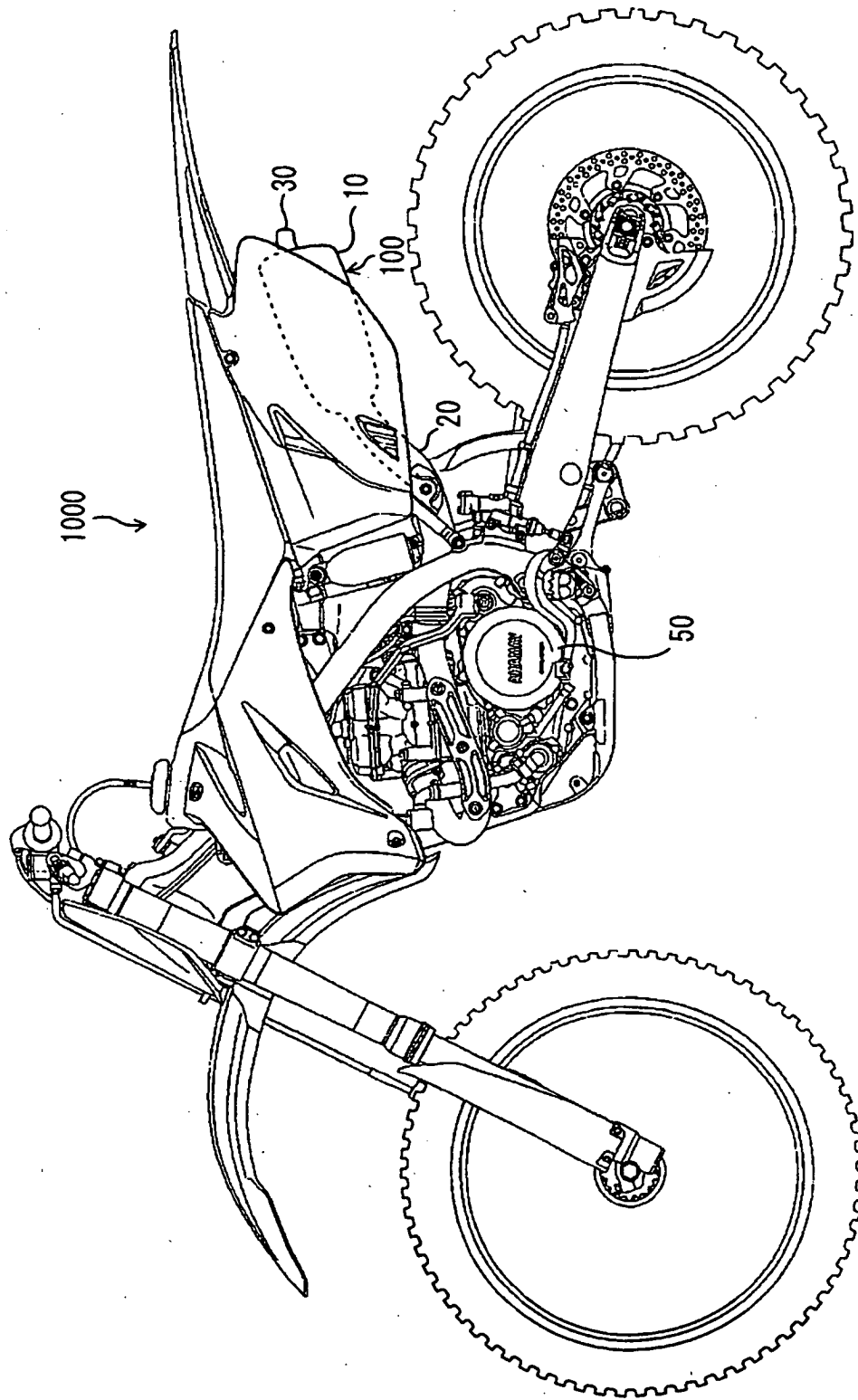
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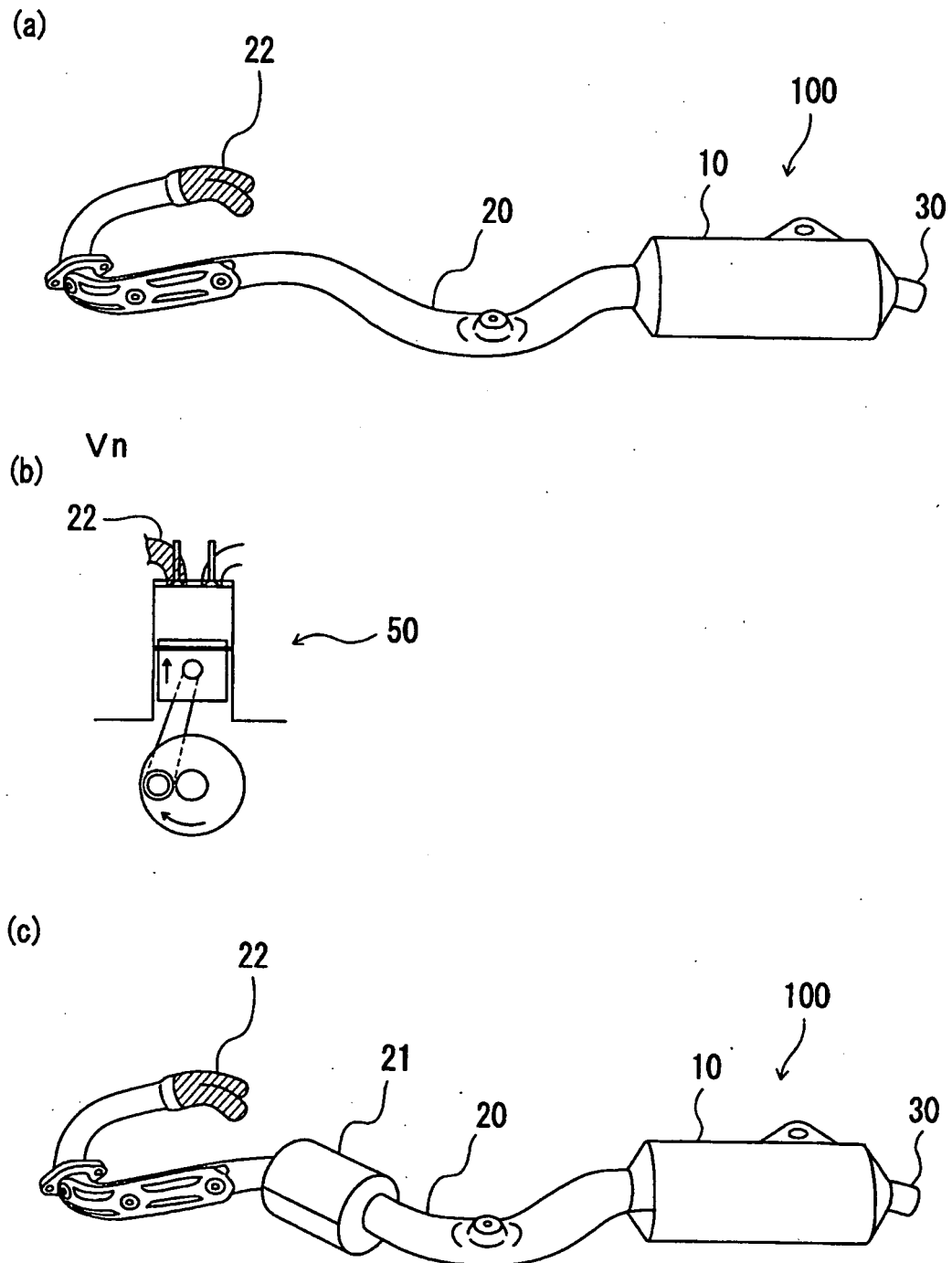
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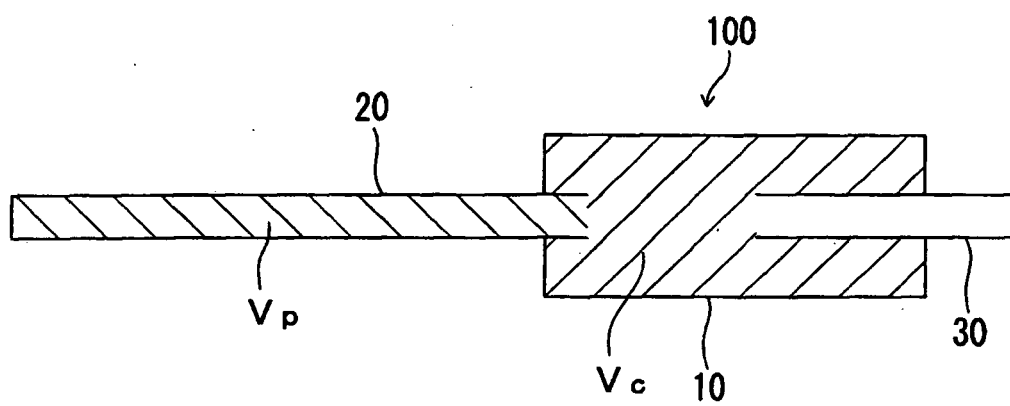
[Fig. 1]



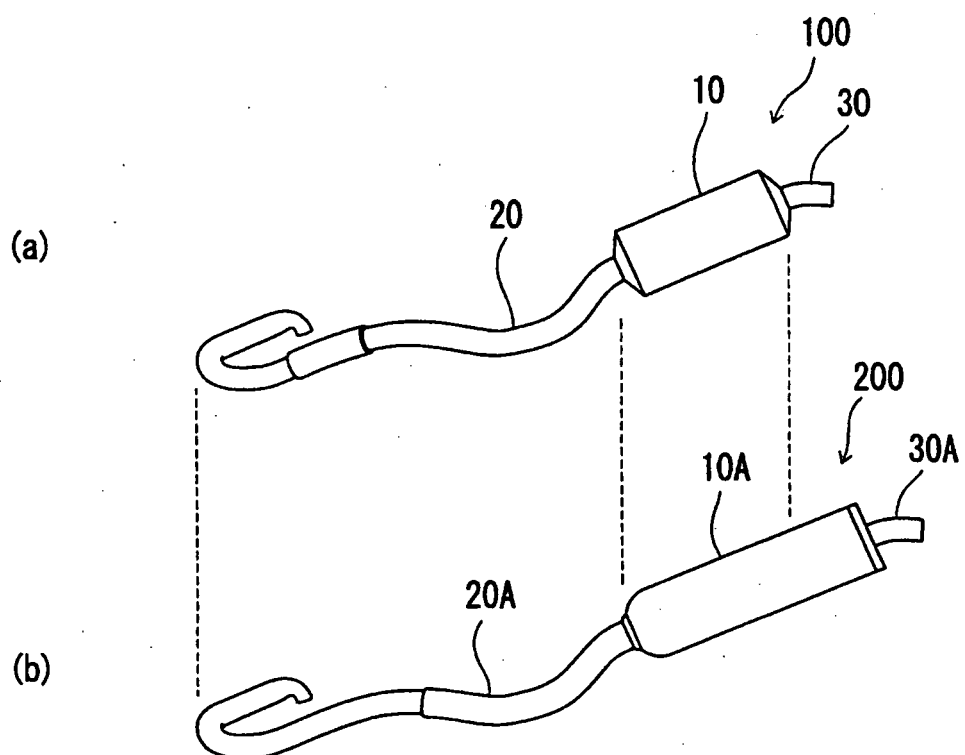
[Fig. 2]



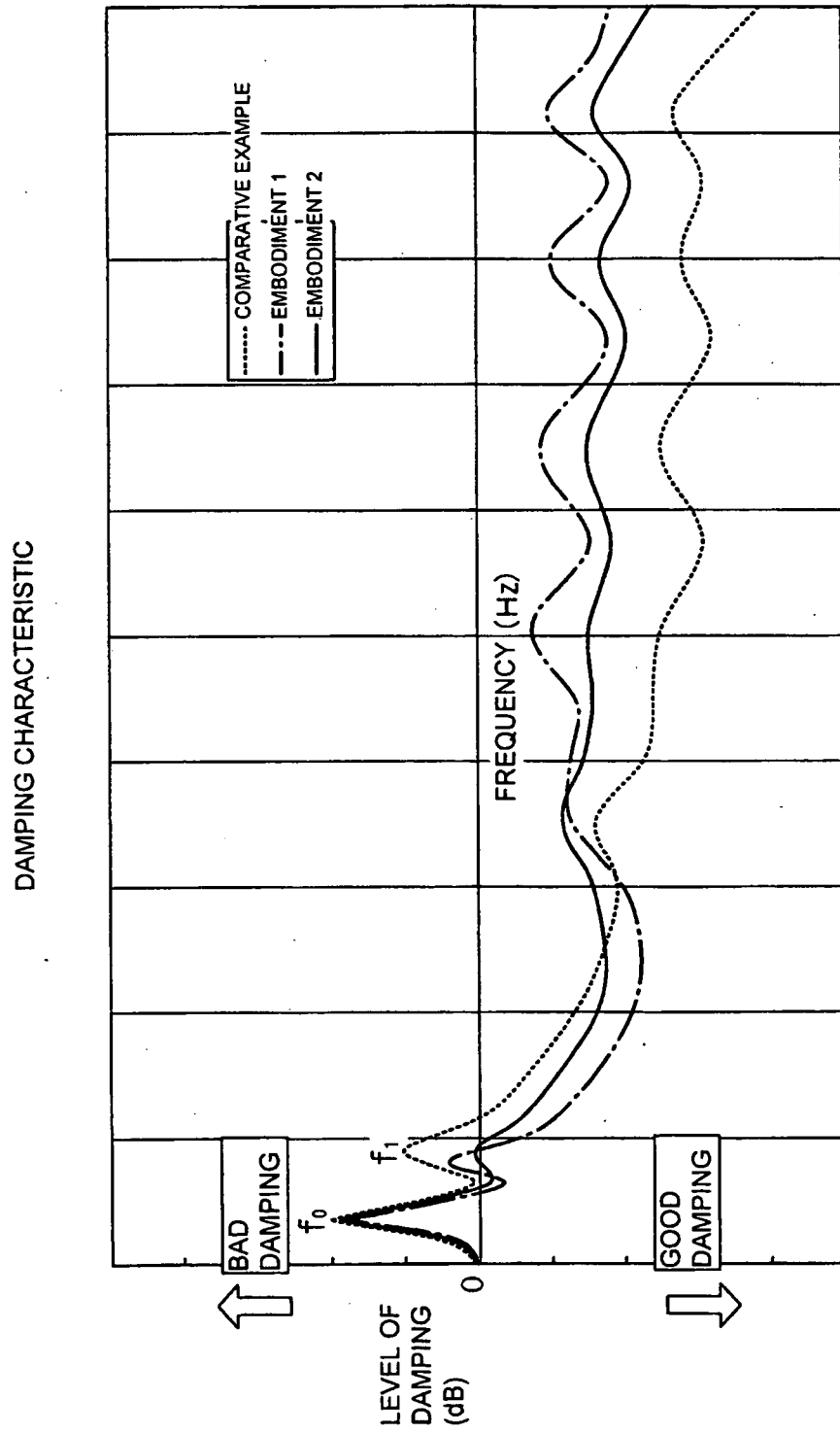
[Fig. 3]



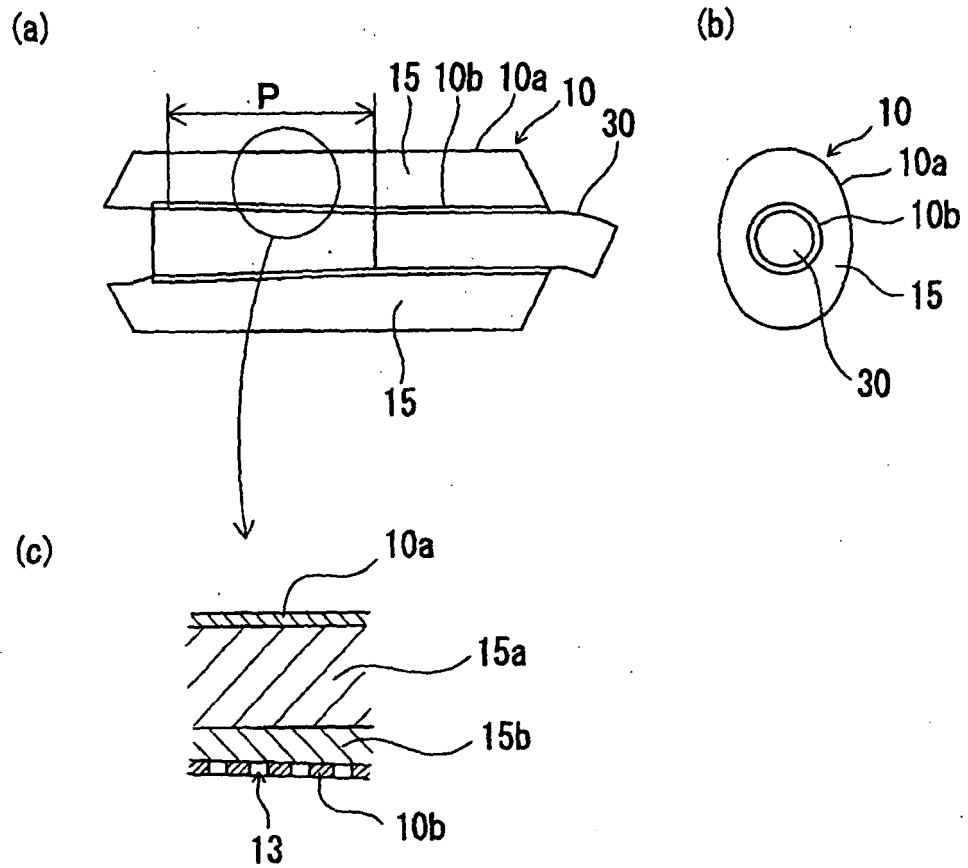
[Fig. 4]



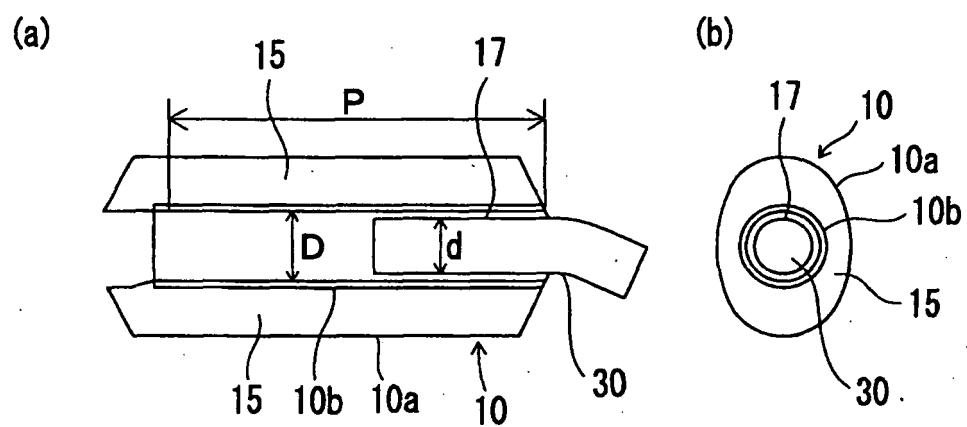
[Fig. 5]



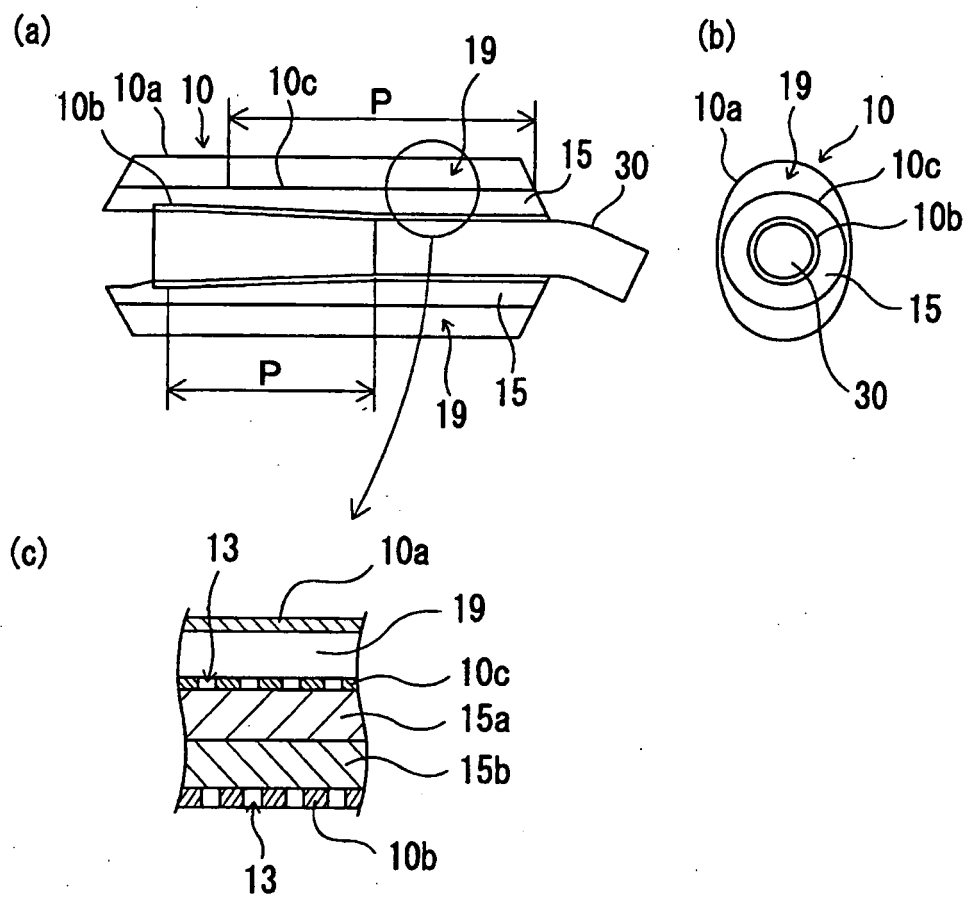
[Fig. 6]



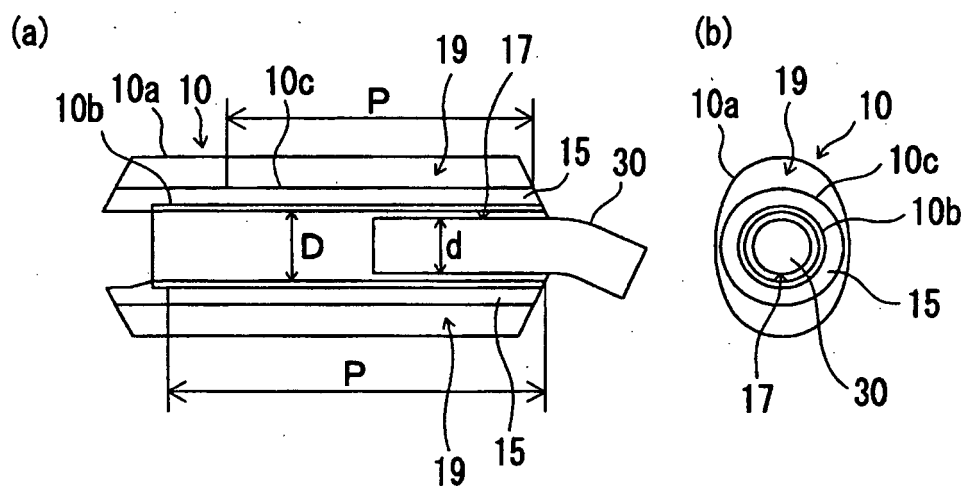
[Fig. 7]



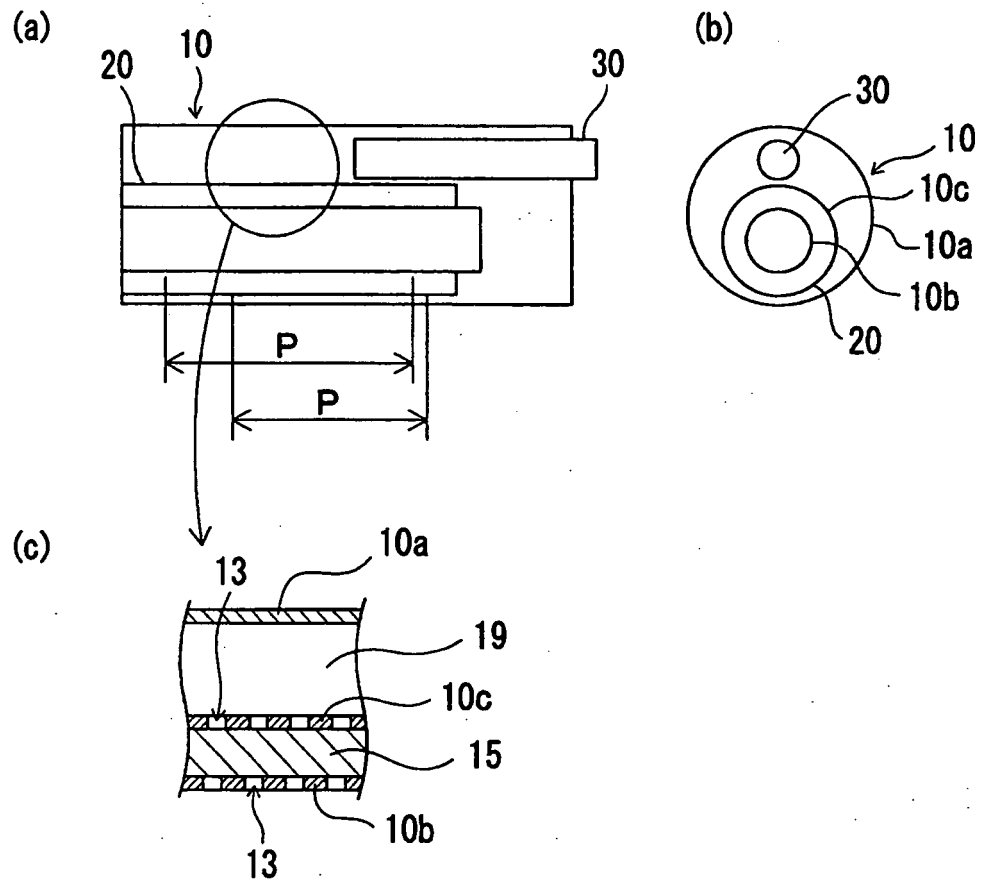
[Fig. 8]



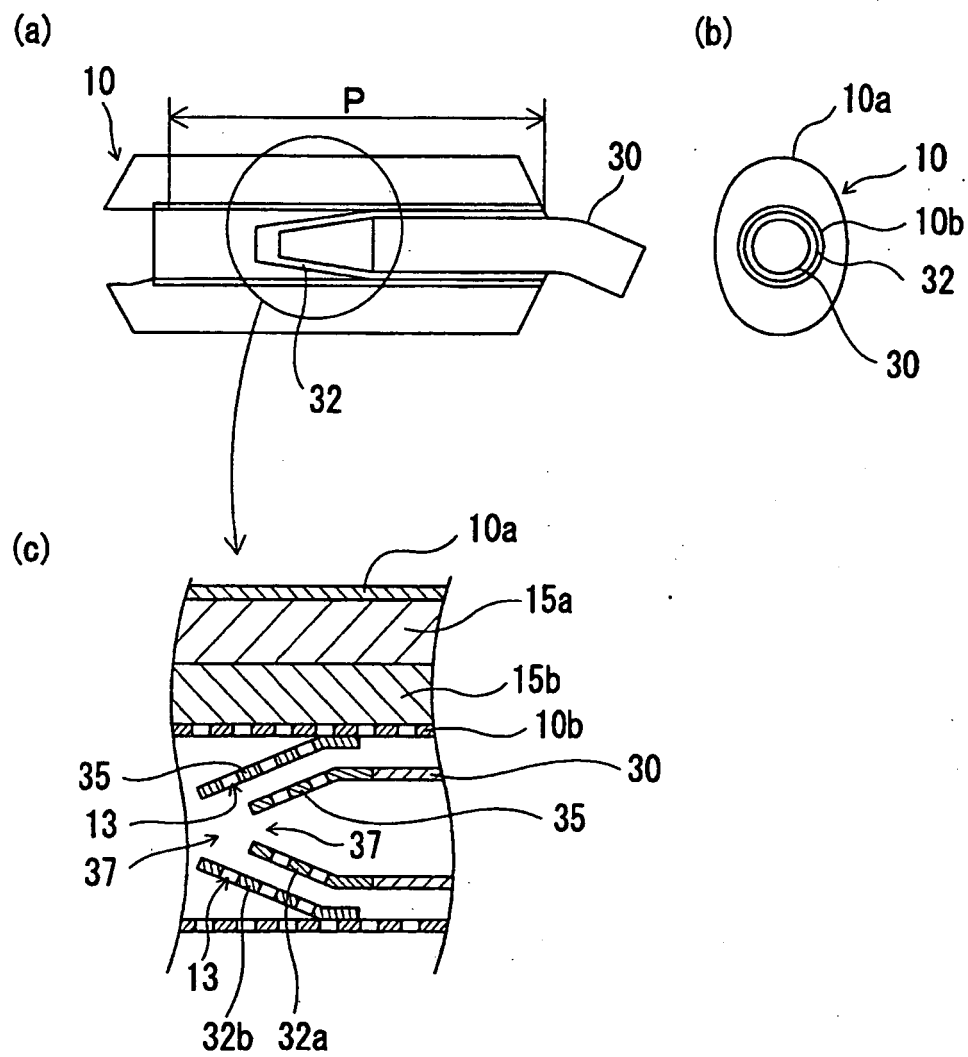
[Fig. 9]



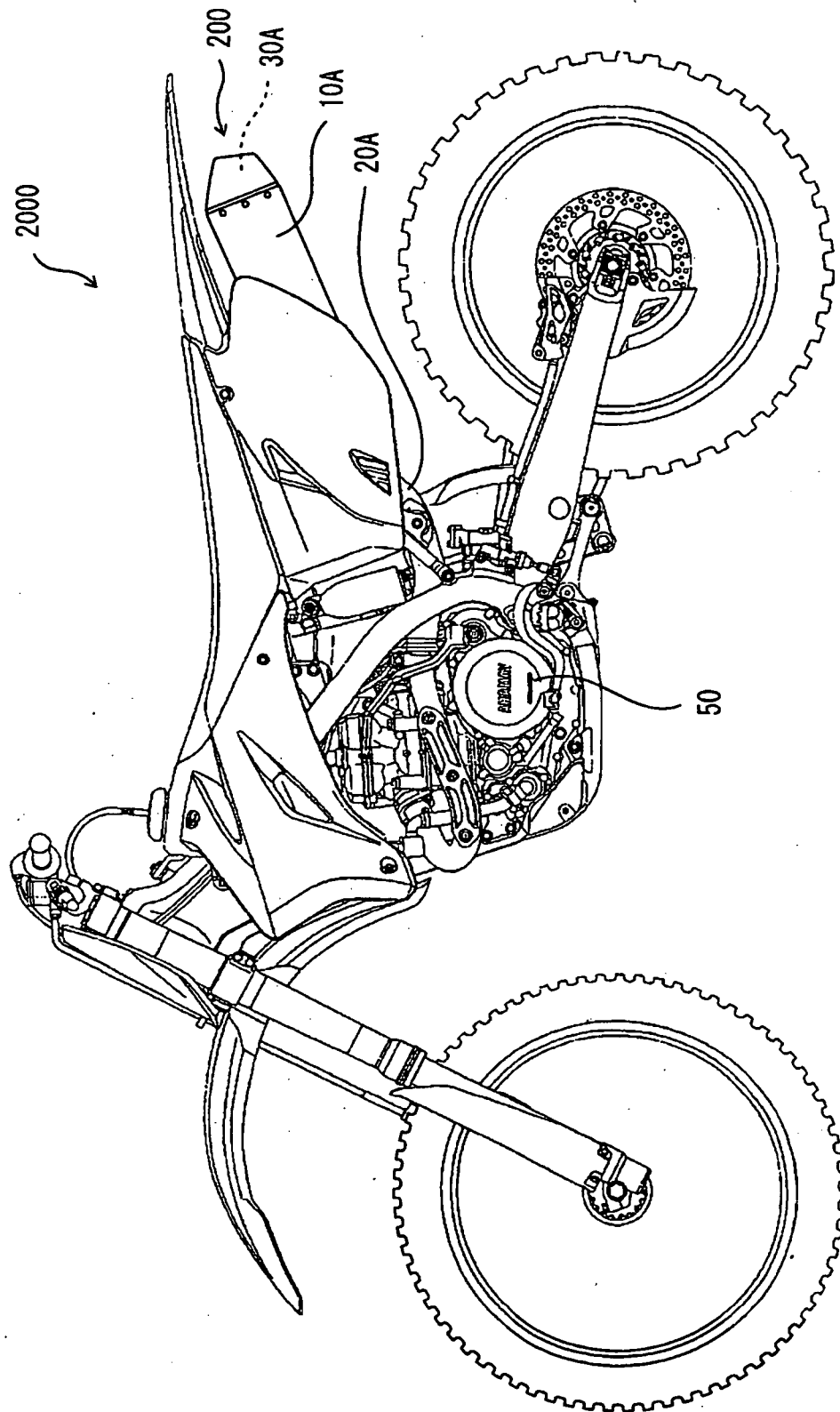
[Fig. 10]



[Fig. 11]



[Fig. 12]



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8312324 A [0003]
- JP 2003184541 A [0003]